CrIS SDR Radiometric Assessment Using CRTM

Denis Tremblay[1], Yong Han[2] , Xin Jin[2], Yong Chen[2], Likun Wang[3]

[1] Science Data Processing Inc., [2] NOAA/NESDIS/STAR, [3]University of Maryland USA.

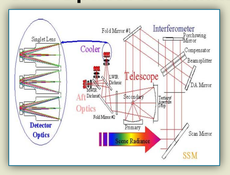
Contact: denis.tremblay@noaa.gov

Abstract

The Crosstrack Infrared Sounder (CrIS) is a spaceborne Fourier Transform Spectrometer (FTS) that was launched into orbit on October 28th 2011 onboard the SUOMI NPP satellite. As part of the ongoing calibration and validation activities, the radiance residuals (observed minus calculated) are analyzed in order to assess the radiometric accuracy. For over 800,000 cases, the measured spectra correspond to location over ocean for cloud free scenes. The top of atmosphere (TOA) radiance is calculated from the modeled sea surface temperature at the CrIS footprint location, the ECMWF atmospheric state, and the Community Radiative Transfer Model (CRTM). The radiance residual shows a radiometric agreement of 0.2K over the window channels. The CrIS SDR radiance products (spectra, geolocation, noise) are essential for assimilation into the NWP weather forecasting system.

Instrument Characteristics and Attributes

CrIS Optical Schematic



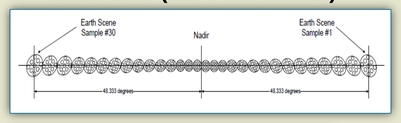
Spectral Characteristics

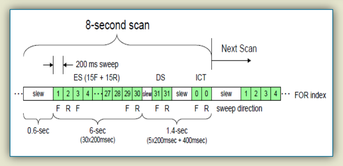
Band	Spectral range [cm^{-1}]	Spectral range [μm]	Band width [cm^{-1}]	Resolution Δσ [cm^{-1}]	MPD [cm]
LW	650 – 1095	15.4 – 9.1	445	0.625	0.8
MW	1210 – 1750	8.3 – 5.7	540	1.25	0.4
SW	2155 – 2550	4.6 – 3.9	395	2.5	0.2

Normal Acquisition Mode

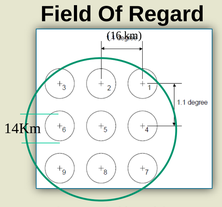
Number of FOV	9
Number of FOR per Scan Line	30
Scan line Acquisition Period	8 seconds
Number of Scan line per day	10800
Number of Frequency Band	3
Total number of Spectra per Day	8.7 Million

Scan Line (2200 Km Swath)

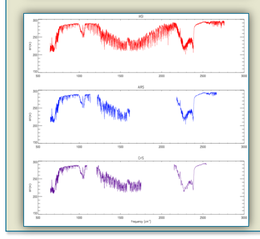




Field Of Regard



1 center, 4 side and 4 corner FOVs in each FOR

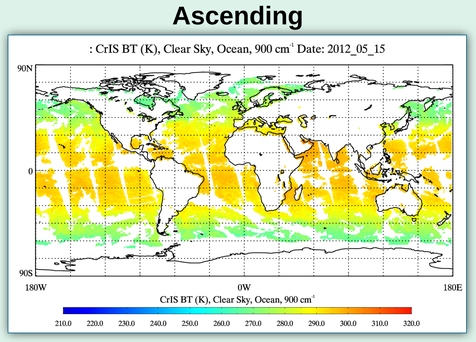


- IASI has full spectral coverage from 645 cm-1 to 2760 cm-1.
- AIRS and CrIS have 3 frequency bands as shown.
- CrIS has coarser spectral resolution in MW and SW. Request to download full spectral resolution (0.625 cm-1 all 3 bands) is under consideration for JPSS-1 satellite (launch planned for 2017).

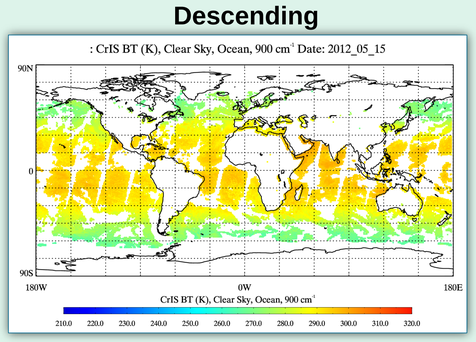
CrIS acquires 8.7 million spectra per day covering over 95% of the Earth surface.

The May 15th 2012 Golden Data Set

Ascending



Descending

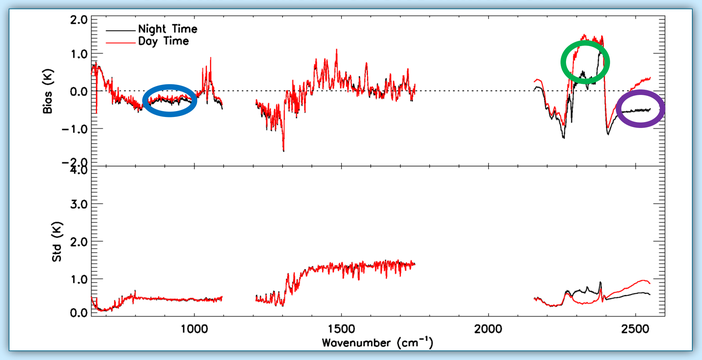


- The May 15th 2012 was selected as a 'Golden Day' because it has several SNO occurrences with other sensors. Out of 8.7 million spectra, over 800,000 are clear sky over ocean. These are shown above. Engineering packet is version 33.
- Cloud Detection: The channels are first ordered according to their loud sensitivity: the highest channels first and the channels closest to the surface last (McNally and Watts, 2003) .
- The overcast variable contains overcast radiances assuming the presence of a black cloud at each of CRTM levels. The height for a particular channel is assigned by finding the level where the difference between the overcast and clear radiances is less than 1%.
- The resulting ranked brightness temperature departures are smoothed with a moving-average filter in order to reduce the effect of instrument noise .

Out of 8.7 M spectra, over 800,000 are clear sky over ocean. This forms the data set used in this analysis.

Overall Radiometric Assessment

Overall BT Mean of CrIS minus CRTM



Window region negative bias may partial contribute from the cloud contamination

NLTE effect over SWIR channels

Ocean BRDF effect

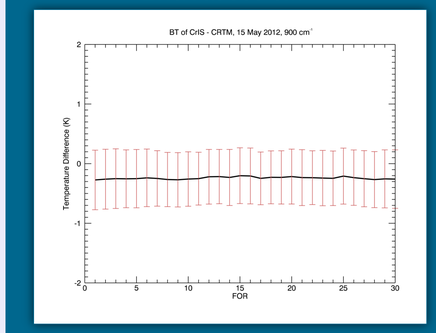
Results shown here are for Engineering Packet (EP) version 33 uploaded on April 11th 2012.

LWIR window channels have a negative bias of about 0.2K - possibly due to the presence of cloud.

CrIS and CRTM agrees to 0.2K over the LWIR window channels.

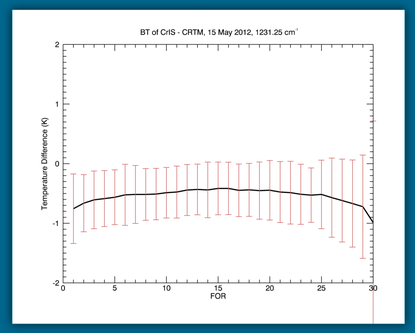
Radiometric Accuracy (CrIS – CRTM) as Function of Viewing Angle (FOR)

LWIR at 900 cm^{-1}



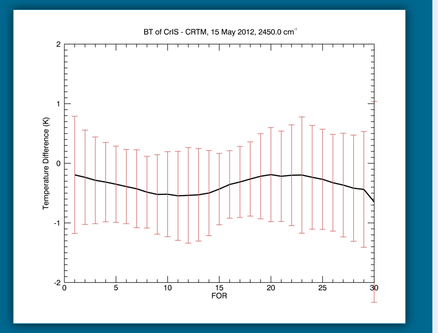
No FOR Dependency

MWIR at 1231.25 cm^{-1}



Convex FOR dependency probably due to water vapor and longer path length.

SWIR at 2450 cm^{-1}

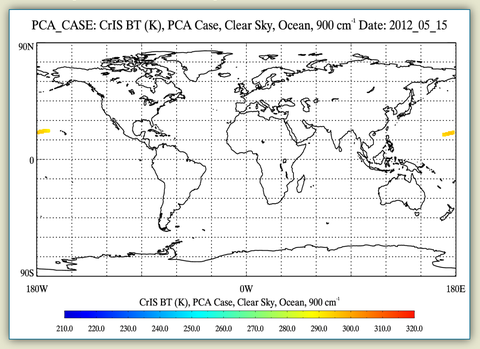


"S" shape FOR dependency is not fully understood.

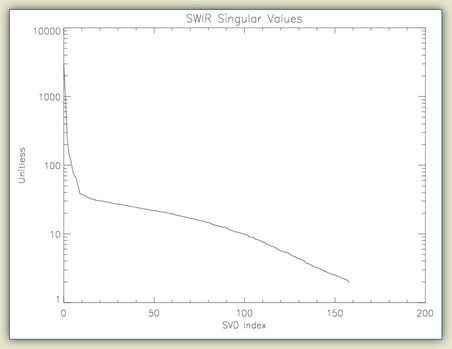
Three FOR dependency shapes may indicate no common CrIS instrumental effects.

Principal Component Analysis (PCA)

737 Spectra ver tropical ocean are selected



Singular Values for SWIR.
The first 15 are significant for all 3 bands.

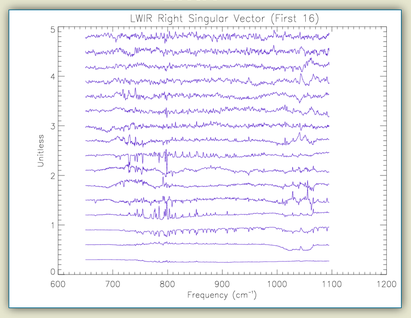


PCA Analysis Processing Steps

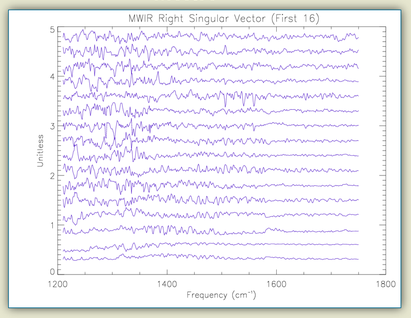
1) A = All spectra
2) A* = (A – A_mean) / NEdN
3) A* = U * S * V^T
(SingularValue decomposition).

S = Diagonal matrix with SV.
V = Right eigenvectors with Frequency dependent signal.
U = Left eigenvector with time dependent signal.

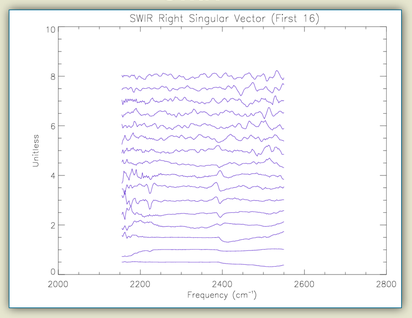
LWIR



MWIR



SWIR



The right eigenvectors (EV) show residual trace gas signal.

- O_3 signal is detected in LWIR EV#2
- CO_2 is detected in LWIR EV6 to 9; SWIR EV3-5-6-7-9,
- H_20 is detected in LWIR EV3-4-8
- CH_4 is detected in MWIR EV 4 to 8.

All these signals have low levels.

PCA analysis of CrIS – CRTM over warm ocean shows spectral signal or residual trace gas along with some CO_2. Signal levels are small.

Summary

- The CrIS measurements agree well with CRTM over window channels.
- FOR Dependency shape is different at the 3 frequencies of interest suggesting no systematic instrumental effects.
- Overall CrIS and CRTM agreement allows the assimilation of CrIS measurement for weather forecasting at NWP.